PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference M/44349-PCT	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/EP 03/14264	International filing date *(day/month/year)* 15.12.2003	Priority date *(day/month/year)* 16.12.2002
International Patent Classification (IPC) or both national classification and IPC H01M6/00		
Applicant NUVERA FUEL CELLS EUROPE S.R.L. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 8 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
15.07.2004	07.04.2005
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Horváth, L Telephone No. +49 89 2399-2110

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP 03/14264

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, Pages

1-10 as originally filed

Claims, Numbers

1-18 as originally filed

Drawings, Sheets

1/3-3/3 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).

   ☐ the language of publication of the international application (under Rule 48.3(b)).

   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:

   ☐ the claims, Nos.:

   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-17
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-17
Industrial applicability (IA)	Yes:	Claims	1-17
	No:	Claims	

2. Citations and explanations

   see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following documents:

D1: US 2001/033956 A1 (GAMBURZEV SERGUEY ET AL) 25 October 2001 (2001-10-25)
D2: US-A-4 769 297 (REISER CARL A ET AL) 6 September 1988 (1988-09-06)
D3: EP-A-0 415 330 (INT FUEL CELLS CORP) 6 March 1991 (1991-03-06)
D4: EP-A-0 328 115 (INT FUEL CELLS CORP) 16 August 1989 (1989-08-16)

1.The problem and object of the application:

1.1. The present application refers to an electrochemical generator based on PEM fuel cells and more particularly to water management in such a fuel cell system. The problem of the application is to achieve a good balance between incoming or reaction generated water and water withdrawn from the cell by evaporation or with the exhaust flow. It is also desired to prevent the sticking of water droplets within the ribs of bipolar plates which may obstruct the reactant feed and thus the current generation process while the PEM is still maintained in a sufficiently humidified state to maintain the necessary level of ion conductivity.

It is an object of the present application to provide an electrochemical generator comprising an alternation of polymer membrane fuel cells and cooling cells for in situ humidification of the gaseous reactants and thereby eliminating the auxiliary circuits. By evaporating at least part of the water used for humidification it is also desired to cool the fuel cell.

1.2. To reach the above mentioned objectives the applicant suggests a system of PEM fuel cells alternated with liquid water fed cooling cells, wherein the cooling cells are separated by an adjacent fuel cell by means of a metallic integral porous wall. The cooling cells are fed with liquid water at a controlled

higher pressure than the pressure of the gaseous reactants supplied to the PEM cells. This way the cooling water passes through the porous wall of the cooling cell and it diffuses into the gaseous reactants supplied to the fuel cells. Part of the water absorbing through the separator wall of the cooling cell is evaporated by the heat produced by the electrochemical reaction, withdrawing at least a part of the heat such generated. The reactant distributors and the coolant water flow fields are made of a reticulated metallic material like nickel alloy or stainless steel. They can take the form of meshes or expanded sheets, single or superposed or in forms of sponges or foams. The reticulated structure of the reactant distributors ensures an easy evaporation of the humidifying water.

2. Novelty:

2.1.Document D1, which is considered to represent the most relevant state of the art, discloses a PEM fuel cell system provided with separate cooling cells interposed between the individual fuel cell units using air as a cooling medium and two gas impermeable metal plates to separate the flow of cooling air from the reactants , from which the subject-matter of claim 1 and 14 differs in that the cooling plates of claim 1 and 14 are using water as a cooling medium and one of the separator plates is formed of a porous liquid permeable material and they allow part of the cooling water flowing through the cooling cell to penetrate on to the air electrode side of the PEM fuel cell.

The subject-matter of claim 1 is therefore novel (Article 33(2) PCT).

2.3. Document D2, discloses a PEM fuel cell system provided with evaporative cooling and humidification of the electrolyte membrane through transporting water from one individual fuel cell unit to the next one through porous hydrophylic separator plates with the help of differential pressures or

the reactants applied inside of the fuel cell units. The difference between the subject matter of claim 1 and 14 and D2 is that in claim 1 and 14 separate cooling cells are provided. A further difference is that in D2 classical ribbed flow field plates are used, compared to the porous three dimensionally reticulated metal flow field plates of the claims 1 and 14.

The subject-matter of claim 1 and 14 is therefore novel (Article 33(2) PCT).

2.4. D3 dicloses a fuel cell system with an evaporative cooler. Water sprayed into a raw fuel stream is evaporated inside the evaporative cooler and thus it cools the cell. However there is no indication of the use of porous walls to transport the cooling and humidifying water from one cell to the other.

The subject-matter of claim 1 and 14 is therefore novel (Article 33(2) PCT).

2.5. D4 refers to a PEM fuel cell system with evaporative cooling. The cells are cooled by vaporizing water on the anode side and removing the water vapor from the cells in the hydrogen exhaust streams. There is no indication of the use of separate cooling cells or of the use of porous walls transporting water from one cell to the another.

The subject-matter of claim 1 and 14 is therefore novel (Article 33(2) PCT).

3. Inventive step:

3.1. D1 discloses a PEM fuel cell system provided with an air cooled condenser for use with the fuel cell stack , the condenser comprising a three dimensionally reticulated porous metal cooling element (par. 25). The problem to be solved by D1 is to achieve a proper water control inside the fuel cell and

to prevent the collecting of product water in the grooves of a flow field plate (par.75). Depending on the operating temperature the fuel cell of D1 can be self humidified or it can be humidified with collected product water and extra water for humidification (par. 128-129). The water used for humidification can also be used for further cooling of the fuel cell stack by evaporating part of it inside the fuel cell. The hydrogen reactant is maintained at a slight overpressure so liquid water passes through the electrolyte membrane.

3.2. From the above considerations it can be seen that the problem of D1 is the same as set forward in the present application. The device and method of D1 for solving the problem is partly similar to the method and device of the application. That is in D1 the ribbed flow field plates are also replaced by a three dimensionally reticulated porous flow field element consisting of nickel foams or interlocking nets (par.96, par.117). These porous flow field plates can assure a more effective removal of product water and it prevents the accumulation of water droplets in the ribs of classical flow field plates. There is similarity also in the ways of cooling the fuel cell. In D1 the cooling function is performed in two ways. First is cooling with the use of cooling cells inserted between the PEM individual cells. Additional cooling is provided by evaporating some of the humidification water. The main difference between the application and D1 is that in D1 the cooling cells use air as a cooling medium and not water as in the application. A further difference is that the cooling cell of D1 is separated by gas impermeable walls from the fuel cells and the humidification water is not fed to the fuel cells from the cooling cells.

The most often used cooling mediums in the fuel cell field are air, water with the possibility to use oil in some cases. Water is also used for humidifying the fuel cell stack and for this reason it presents the advantage of performing both functions in the same time. This is the reason why a skilled man would consider replacing air as a coolant medium with water. As water can perform both cooling and humidification a skilled man would consider the possible ways to bring these two functions together and obtain a simpler construction

and operation of the cell. It is known in the art that porous hydrophilic separator plates can be used between individual fuel cells and water can migrate from one cell to the other driven by a differential pressure. Such a device is described in D2 (see D2, col.1 lines 7-12, lines 32-48, col 1., line 60 - col 2., 8). In D2 the cooling of the cells is not performed by additional cooling cells but instead the role of the cooling cells is entirely taken over by evaporation of some of the water used to humidify the stack. The hydrophilic separator plates used in D2 are made of graphite unlike in the application where they are made of a porous metal. In D1 however we find indication that the porous metal plates provide advantages when used for transmitting water (D1, par. 75).

3.3. The solution proposed in claims 1 and 14 of the present application cannot be considered as involving an inventive step (Article 33(3) PCT) for the above mentioned reasons.

Re Item VII

Certain defects in the international application

Claim 18 contains references to the description and the drawings. According to Rule 6.2(a) PCT, claims should not contain such references except where absolutely necessary, which is not the case here.